KEY CONCEPT

3.3 Technology improves the ways people use energy.

BEFORE, you learned

- Energy can change forms
- When energy changes forms, the overall amount of energy remains the same
- Energy conversions usually produce unwanted forms of energy

NOW, you will learn

- How technology can improve energy conversions
- About advantages and disadvantages of different types of energy conversions
- How technology can improve the use of natural resources

VOCABULARY

solar cell p. 88

EXPLORE Solar Cells

Why does a solar calculator need a large solar cell?

PROCEDURE

1. Measure the area of the calculator's solar cell. (**Hint:** area = length • width)
2. Turn the calculator on. Make sure that there is enough light for the calculator to work.
3. Gradually cover the solar cell with the index card. Observe the calculator's display as you cover more of the cell.
4. Measure the uncovered area of the solar cell when the calculator no longer works.

MATERIALS

- solar calculator without backup battery
- ruler
- index card

WHAT DO YOU THINK?

- How much of the solar cell is needed to keep the calculator working?
- Why might a solar calculator have a solar cell that is larger than necessary?

MIND MAP

Use a mind map to take notes about technology that improves energy conversions.

Technology improves energy conversions.

In many common energy conversions, most of the wasted energy is released as heat. One example is the common incandescent light bulb. Amazingly, only about 5 percent of the electrical energy that enters an incandescent light bulb is converted into light. That means that 95 percent of the electrical energy turns into unwanted forms of energy. Most is released as heat and ends up in the form of thermal energy in the surrounding air. To decrease this amount of wasted energy, scientists have investigated several more efficient types of lights.

Efficient Lights

Research to replace light bulbs with a more energy-efficient source of light has resulted in the light-emitting diode, or LED. LEDs have the advantage of converting almost all of the electrical energy they use into light.

The first LEDs were not nearly as bright as typical light bulbs, but over time scientists and engineers have been able to produce brighter LEDs. LEDs have many uses, including television remote controls, computer displays, outdoor signs, giant video boards in stadiums, and traffic signals. LEDs are also used to transmit information through fiber optic cables that connect home audio and visual systems.

CHECK YOUR READING How are LEDs more efficient than incandescent lights?

LEDs that produce infrared light are used in remote controls.

Efficient Cars

Another common but inefficient energy conversion is the burning of gasoline in cars. A large percentage of gasoline's chemical energy is not converted into the car's kinetic energy. Some of the kinetic energy is then wasted as heat from the car's engine, tires, and brakes. Here, too, efficiency can be improved through advances in technology.

Fuel injectors, common in cars since the 1980s, have improved the efficiency of engines. These devices carefully monitor and control the amount of gasoline that is fed into a car's engine. This precise control of fuel provides a significant increase in the distance a car can travel on a tank of gasoline. More recently, hybrid cars have been developed. These cars use both gasoline and electrical energy from batteries. These cars are very fuel efficient. Even better, some of the kinetic energy lost during braking in hybrid cars is used to generate electrical energy to recharge the car's batteries.

Hybrid cars may look very similar to typical gasoline-powered cars, but their engines are different.

Technology improves the use of energy resources.

Much of the energy used on Earth comes from fossil fuels such as coal, petroleum, and natural gas. However, the supply of fossil fuels is limited. So, scientists and engineers are exploring the use of several alternative energy sources. Today, for example, both solar energy and wind energy are used on a small scale to generate electrical energy.

Solar energy and wind energy have several advantages compared to fossil fuels. Their supply is not limited, and they do not produce the same harmful waste products that fossil fuels do. However, there are also many obstacles that must be overcome before solar energy and wind energy, among other alternative energy sources, are as widely used as fossil fuels.

CHECK YOUR READING What are the advantages of solar energy and wind energy as compared to fossil fuels?

Solar Energy

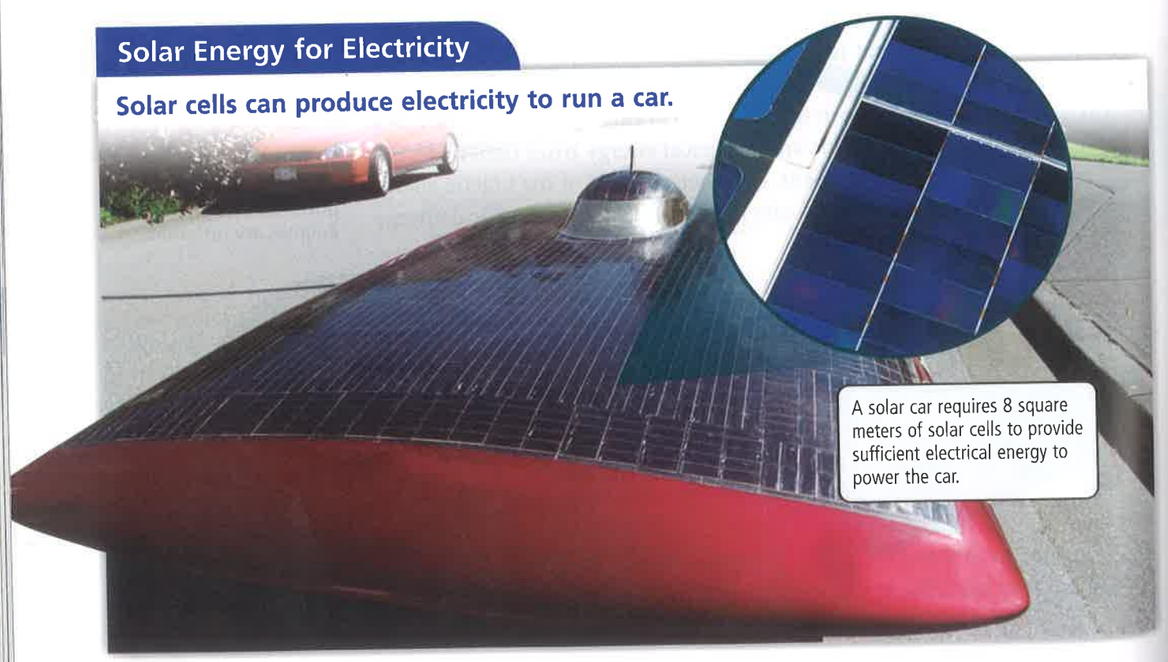
VISUALIZATION CLASSZONE.COM

Observe how solar cells produce electricity.

Solar cells are important in today's solar energy technology. Modern **solar cells** are made of several layers of light-sensitive materials, which convert sunlight directly into electrical energy. Solar cells provide the electrical energy for such things as satellites in orbit around Earth, hand-held calculators, and, as shown below, experimental cars.

Solar Energy for Electricity

Solar cells can produce electricity to run a car.



A solar car requires 8 square meters of solar cells to provide sufficient electrical energy to power the car.

Solar cells produce electrical energy quietly and cleanly. However, they are not yet commonly used because the materials used to make them are very expensive. What's more, solar cells are not very efficient in producing electrical energy. Large numbers of solar cells produce only a relatively small amount of electrical energy. Typical solar cells convert only about 12 to 15 percent of the sunlight that reaches them into electrical energy. However, solar cells currently being developed could have efficiencies close to 40 percent.

Solar energy can be used in homes to provide heat and electrical energy.

In addition to converting the Sun's light directly into electrical energy, people have used the Sun's radiation for heating. In ancient Rome, glass was used to trap solar energy indoors so that plants could be grown in the winter. Today radiation from the Sun is still used to grow plants in greenhouses and to warm buildings. The photograph above shows a house that uses solar energy in both ways. The solar cells on the roof provide electrical energy, and the large windows help to trap the warmth. In fact, some solar power systems also use that warmth to produce additional electrical energy.

CHECK YOUR READING How can energy from the Sun be used by people?

INVESTIGATE Solar Energy

What improves the collection of solar energy?

SKILL FOCUS Observing

MATERIALS
- 2 plastic cups
- white plastic
- black plastic
- 2 rubber bands
- scissors
- 2 thermometers
- stopwatch

for Challenge:
- aluminum foil

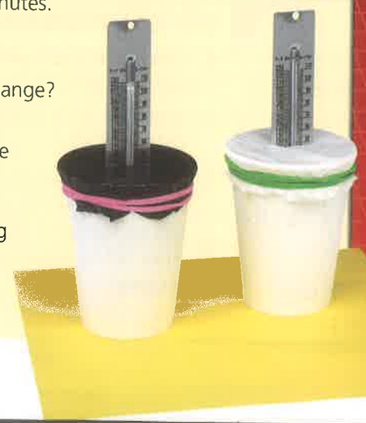
TIME 20 minutes

PROCEDURE

1. Cover the top of one cup with white plastic, and cover the top of the other cup with black plastic. Secure the plastic with a rubber band.
2. Use the scissors to make a small hole in the center of each cup's plastic lid. Insert a thermometer through each opening.
3. Place the cups in direct sunlight, and record their temperatures every minute for 10 minutes.

WHAT DO YOU THINK?
- Which cup showed a greater temperature change? Why do you think this happened?
- Make a line graph of your results to show the change in temperature in each cup.

CHALLENGE Try the experiment again, using aluminum foil instead of white plastic. How do the results differ with the aluminum foil? Why might this be the case?



INFER Why might so many windmills be needed at a windfarm?

Wind Energy

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Find out more about alternative energy sources.

For many centuries, people have used the kinetic energy of wind to sail ships, and, by using windmills, to grind grain and pump water. More recently, windmills have been used to generate electrical energy. In the early 1900s, for example, windmills were already being used to produce electrical energy in rural areas of the United States.

Like the technological advances in the use of solar energy, advances in capturing and using wind energy have helped to improve its efficiency and usefulness. One way to better capture the wind's energy has been to build huge windmill farms in areas that receive a consistent amount of wind. Windmill farms are found in several states, including Texas, California, and Washington. Other methods of more efficiently capturing wind energy include the use of specially shaped windmill blades that are made of new, more flexible materials.

CHECK YOUR READING How has the use of wind energy changed over time?

3.3 Review

KEY CONCEPTS

1. Provide an example of a common technology that does not efficiently convert energy. Explain.
2. Describe two ways in which hybrid cars are more energy-efficient than gasoline-powered cars.
3. List two advantages and two disadvantages of solar power.

CRITICAL THINKING

4. **Compare and Contrast** How are LEDs similar to incandescent light bulbs? How are they different?
5. **Synthesize** What are two ways in which the Sun's energy can be captured and used? How can both be used in a home?

CHALLENGE

6. **Draw Conclusions** Satellites orbiting Earth use solar cells as their source of electrical energy. Why are solar cells ideal energy sources for satellites?

MATH in SCIENCE

SKILL: USING FORMULAS

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Indoor ice rinks require cooling systems that can keep ice frozen even when the outdoor temperature is 95°F.

Cool Efficiency

Energy efficiency is important because energy supplies are limited. The energy used by appliances such as air conditioners is measured in British thermal units, or BTUs. One BTU warms one pound of water by 1°F. The cooling ability of an air conditioner is measured by the number of BTUs it can move. Consider the number of BTUs that an air conditioning system must move in an ice rink.

An air conditioner typically has an energy efficiency ratio (EER) rating. The EER measures how efficiently a cooling system operates when the outdoor temperature is 95°F. The EER is the ratio of cooling per hour to the amount of electricity used, which is measured in watts. The higher the EER, the more energy efficient the air conditioner is.

$$\text{EER} = \frac{\text{BTUs/hr}}{\text{watts used}}$$

Example

Suppose an air conditioner uses 750 watts of electricity to cool 6000 BTUs per hour at 95°F. Calculate the air conditioner's EER.

(1) Use the formula above to calculate the EER.

$$\text{EER} = \frac{\text{BTUs/hr}}{\text{watts used}}$$

(2) Enter the known values into the formula.

$$\text{EER} = \frac{6000\ \text{BTUs/hr}}{750\ \text{watts used}}$$

(3) Solve the formula for the unknown value.

$$\text{EER} = \frac{6000\ \text{BTUs/hr}}{750\ \text{watts used}} = 8$$

ANSWER EER = 8 BTUs/hr per watt used

Answer the following questions.

1. What is the EER of a cooling system that uses 500 watts of electricity to move 6000 BTUs per hour at 95°F?
2. What is the EER of a cooling system that uses 1500 watts of electricity to move 12,000 BTUs per hour at 95°F?
3. Which air conditioner in the two questions above is more efficient?

CHALLENGE How many BTUs per hour would an air conditioner move at 95°F if it had an EER of 10 and used 1200 watts of electricity?

3 Chapter Review

the BIG idea

Energy has different forms, but it is always conserved.

CONTENT REVIEW
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KEY CONCEPTS SUMMARY

3.1 Energy exists in different forms.

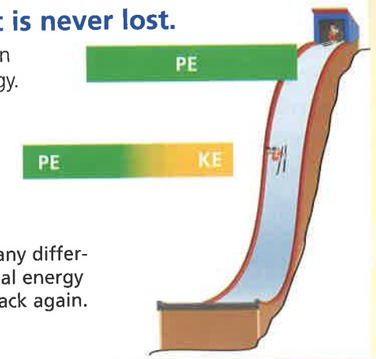
- Energy is the ability to cause a change.
- Different forms of energy produce changes in different ways.
- Kinetic energy depends on mass and speed.

Potential energy depends on position and chemical composition.

VOCABULARY
energy p. 72
kinetic energy p. 74
potential energy p. 75

3.2 Energy can change forms but is never lost.

- Energy often needs to be transformed in order to produce a useful form of energy.
- The law of conservation of energy states that energy is never created or destroyed.



Energy can be transformed in many different ways, including from potential energy (PE) to kinetic energy (KE) and back again.

VOCABULARY
law of conservation of energy p. 82
energy efficiency p. 83

3.3 Technology improves the ways people use energy.

- Different forms of technology are being developed and used to improve the efficiency of energy conversions.
- Solar cells convert sunlight into electrical energy.

New solar cells convert light into electrical energy more efficiently than those in the past.

VOCABULARY
solar cell p. 88

Reviewing Vocabulary

Review vocabulary terms by making a four square diagram for each term as shown in the example below. Include a definition, characteristics, examples from real life, and, if possible, nonexamples of the term.

Definition	Characteristics
the energy of motion	depends on an object's mass and speed
KINETIC ENERGY	
Example	**Nonexample**
a rolling soccer ball	a soccer ball that has stopped rolling

1. energy
2. potential energy
3. conservation of energy
4. energy efficiency

Reviewing Key Concepts

Multiple Choice *Choose the letter of the best answer.*

5. All forms of energy are a combination of
   - **a.** mechanical energy and chemical energy
   - **b.** chemical energy and kinetic energy
   - **c.** potential energy and thermal energy
   - **d.** potential energy and kinetic energy

6. Which type of energy is transmitted by vibrations of air?
   - **a.** electromagnetic
   - **b.** sound
   - **c.** nuclear
   - **d.** chemical

7. When energy is converted from one form to another, what is usually produced?
   - **a.** chemical energy
   - **b.** gravity
   - **c.** heat
   - **d.** nuclear energy

8. An object's kinetic energy is determined by its
   - **a.** position and composition
   - **b.** speed and position
   - **c.** mass and speed
   - **d.** height and width

9. Which of the following is a conversion from chemical energy to mechanical energy?
   - **a.** a dark light bulb starting to glow
   - **b.** food being heated in an oven
   - **c.** a ball rolling down a hill
   - **d.** a person lifting a weight

10. An energy-efficient electric fan converts a large portion of the electrical energy that enters it into
    - **a.** an unwanted form of energy
    - **b.** kinetic energy of the fan blades
    - **c.** thermal energy in the fan's motor
    - **d.** sound energy in the fan's motor

11. The energy in wind used to generate electricity is
    - **a.** chemical energy
    - **b.** sound energy
    - **c.** potential energy
    - **d.** kinetic energy

12. A skier on a hill has potential energy due to
    - **a.** speed
    - **b.** energy efficiency
    - **c.** compression
    - **d.** position

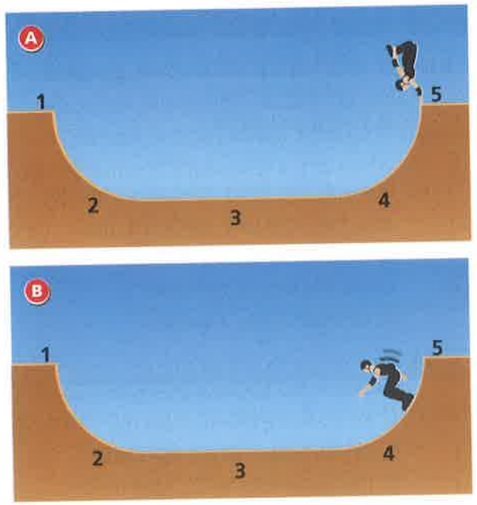
Short Answer *Write a short answer to each question.*

13. Explain how the law of conservation of energy might apply to an energy conversion that you observe in your daily life.

14. Describe a situation in which chemical energy is converted into mechanical energy. Explain each step of the energy conversion process.

Thinking Critically

The illustrations below show an in-line skater on a ramp. Use the illustrations to answer the next five questions.



15. OBSERVE At what point in the illustrations would the skater have the most potential energy? the most kinetic energy? Explain.

16. SYNTHESIZE At what point in illustration B will the skater's kinetic energy begin to be changed back into potential energy? Explain.

17. INFER When the skater's kinetic energy is changed back into potential energy, will this amount of potential energy likely be equal to the skater's potential energy in illustration A? Why or why not?

18. PREDICT Describe how energy may appear to decrease in the example shown above. What energy conversions that produce unwanted forms of energy are occurring? Explain.

19. SYNTHESIZE Draw colored bars that might represent the potential energy and kinetic energy of the skater at each of the five labeled points on illustration A. Explain why you drew the bars the way you did. (**Hint:** See the illustration on p. 79.)

20. SYNTHESIZE How are plants and solar cells similar? How are the ways in which they capture sunlight and convert it into other forms of energy different? Explain.

21. COMPARE Explain how energy sources such as solar energy and wind energy have similar problems that must be overcome. How have scientists tried to address these problems?

22. INFER Suppose that one air conditioner becomes very hot when it is working but another air conditioner does not. Which air conditioner is more energy efficient? How can you tell?

23. DRAW CONCLUSIONS Suppose a vacuum cleaner uses 100 units of electrical energy. All of this energy is converted into thermal and sound energy (from the motor), and into the kinetic energy of air being pulled into the vacuum cleaner. If 60 units of electrical energy are converted into thermal energy and sound energy, how much electrical energy is converted into the desired form of energy? How do you know?

24. COMMUNICATE Describe a process in which energy changes forms at least twice. Draw and label a diagram that shows these energy conversions.

the BIG idea

25. APPLY Look again at the photograph on pages 68 and 69 and consider the opening question. How might your answer have changed after reading the chapter?

26. COMMUNICATE How have your ideas about energy and its different forms changed after reading the chapter? Provide an example from your life to describe how you would have thought of energy compared to how you might think about it now.

UNIT PROJECTS

If you need to do an experiment for your unit project, gather the materials. Be sure to allow enough time to observe results before the project is due.

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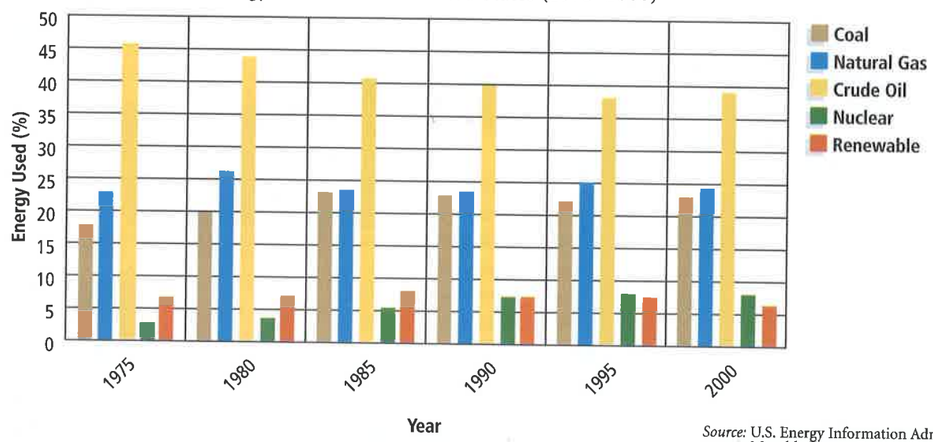
Interpreting Graphs

Study the graph below. Then answer the first five questions.

Energy Sources in the United States (1975–2000)



Source: U.S. Energy Information Administration, Monthly Energy Review (June 2003)

1. In which year did the greatest percentage of energy used in the United States come from crude oil?
- **a.** 1975
- **b.** 1980
- **c.** 1995
- **d.** 2000

2. What three sources of energy account for about 80 percent of all energy used in each year shown?
- **a.** coal, crude oil, nuclear
- **b.** natural gas, crude oil, renewable
- **c.** coal, natural gas, crude oil
- **d.** crude oil, nuclear, renewable

3. Which sources of energy show a greater percentage in 2000 as compared to 1980?
- **a.** crude oil, renewable
- **b.** natural gas, crude oil
- **c.** coal, nuclear
- **d.** coal, crude oil

4. The use of which energy source tended to decrease between 1975 and 2000?
- **a.** coal
- **b.** natural gas
- **c.** crude oil
- **d.** nuclear

5. The use of which source of energy steadily increased between 1975 and 1995?
- **a.** coal
- **b.** crude oil
- **c.** nuclear
- **d.** renewable

Extended Response

Answer the questions in detail. Include some of the terms from the word box on the right. Underline each term you use in your answers.

chemical energy	potential energy
electrical energy	sound energy
mechanical energy	thermal energy

6. When gasoline is burned in a moving car's engine, which forms of energy are being used? Which forms of energy are produced? Explain.

7. Name two appliances in your home that you believe are inefficient. What about them indicates that they may be inefficient?